REMARKS/ARGUMENTS

I. New Claims

The new claims discussed below were drafted with the various prior art references cited in the May 14, 2003 Office action in mind (i.e., primarily U.S. Patent No. 4,037,102 to Hoyle et al. (hereafter "Hoyle") and the article "Ultimate Quantum Efficiency of a Superconducting Hot Electron Photodetector" by Il'in et al. (hereafter "Il'in"), and secondarily U.S. Patent No. 4,987,305 to Bornstein (hereafter "Bornstein"), U.S. Patent No. 5,828,068 to Weirauch (hereafter "Weirauch"), and the "Appl. Phys. Lett. 63(4) of Ghis et al. (hereafter "Ghis"). Collectively, all of the above-identified references are referred to herein as the "Cited References."

A. New independent claims 25 and 31

New independent claims 25 and 31 are similar to claims 1 and 7, respectively, but do not include the time resolving limitations. Instead, new claims 25 and 31 include the limitations of "providing a mirror to reflect the at least one photon unto said superconducting strip in the event the at least one photon is not directly incident upon the superconducting strip" and "a mirror optically coupled with the superconducting film, the mirror arranged to reflect the one or more photons toward the superconducting film," respectively. Support for new claims 25 and 31 can be found in Figs. 8A – 8C, and the accompanying text on page 20 of the present application. None of the Cited References disclose or suggest the use of a mirror to enhance the performance of a detector capable of detecting single photons. Moreover, the Bornstein and Weirauch references involve IR (Infra-Red) sensors, which are not amenable to the use of mirrors due to their semi- or un-transparent characteristics. As such, it is believed that new claims 25 and 31 are patentable under 35 U.S.C. §§ 102 and 103 and in form for allowance, and such indication is respectfully requested.

B. New dependent claims 26-30 and 32-36

Dependent claims 26, 27, 32 and 33 include limitations similar to new claims 37 and 38 discussed in detail is subsection C below. Generally, claims 26 and 32 require that the

superconducting trip be maintained substantially below its critical temperature such that said superconducting film is maintained in the superconducting state below its superconducting transition region. Claims 27 and 32 require a NbN superconduction maintained at or below 4 Kelvin – 10 Kelvin.

It is respectfully submitted that the particular characteristics required by the inventions of claims 26-27 and 32-33 distinguish the inventions over any teachings of Hoyle and Il'in. Particularly, as illuminated by the discussion below in subsection C, combining Hoyle with Il'in to render claims 26-27 and 32-33 obvious would be improper as the invention of claims 26-27 and 32-33 is operating in regions that Il'in teaches will <u>not</u> work for single photon detection.

Dependent claims 28, 29, 34, and 35 include a limitation directed toward an antireflective coating. Support for an antireflective coating is found at page 20, line 27, for example. Dependent claims 30 and 36 include a limitation directed toward a cryogenic amplifier. Support for a cryogenic amplifier is found on page 13, lines 9-29.

The various additional features of the single photon detector required by new dependent claims 26, 30 and 32-36 are not disclosed or suggested by the Hoyle, Il'in or the other references, alone or in combination. As such, it is believed that new dependent claims 26-30 and 32-36 are patentable under 35 U.S.C. §§ 102 and 103 and in form for allowance, and such indication is respectfully requested. New dependent claims 26-30 and 32-36 depend from new independent claims 25 and 31, respectively. Thus, for at least the same reasons recited above with regard to claims 25 and 31, it is believed that claims 26-30 and 32-36 are also patentable over the Cited References.

C. New independent claims 37 and 39

New independent claims 37 and 39 include the same limitations as claims 1 and 7, respectively, as amended in the April 30, 2002 Response to Office Action. As those claims 1 and 7 were subsequently rejected under 35 U.S.C. § 103 over the combination of Hoyle in view of Il'in, the discussion below addresses the patentability of new claims 37 and 39 over Hoyle in view of Il'in. More particularly, the April 30, 2002 amendments to claims 1 and 7 were

responsive to the February 1, 2002 Office action in which claim 1 was rejected under 35 U.S.C. § 102 as being anticipated by Il'in and claims 1 and 7 were rejected under 35 U.S.C. § 103 as being unpatentable over Hoyle. In the subsequent May 15, 2002 Office action (in response to April 30, 2002 amendments), claims 1 and 7 remained rejected, but only under 35 U.S.C. § 103 under the combination of Hoyle in view of Il'in.

New claims 37 and 39 also include additional limitations in comparison to claims 1 and 7 (as amended in the response dated April 30, 2002). Particularly, new claims 37 and 39 as submitted herewith more particularly require that the superconductor be maintained at a temperature <u>substantially below</u> its critical temperature such that the superconducting film <u>is maintained in the superconducting state below the superconducting transition region</u>. As claims 37 and 39 are similar to claims 1 and 7, respectively, but add the above described additional limitations, the potential obviousness rejection of claims 37 and 39 over the combination of Hoyle in view of Il'in under 35 U.S.C. § 103 is prospectively addressed herein.

On page 9 of the May 14, 2003 Office action, the Examiner posits that the "temperature ranges taught by the Hoyle and Il'in references are considered to be very similar, and possibly even overlapping considering the uncertainty in the width of a 'superconducting transition region; and the understanding that the a 'superconducting transition region typically comprises regions above and below a labeled 'critical temperature'." It is respectfully submitted that the above-described limitation of claims 37 and 39 and the discussion provided below resolve any perceived ambiguity in overlap of temperature and transition region, and new claims 37 and 39 are patentable over the combination of Hoyle and Il'in.

A prima facie case of obviousness under 35 U.S.C. § 103 requires that there be a (1) suggestion or motivation to modify the reference or to combine reference teachings, (2) a reasonable expectation of success found in the prior art, and not based on the applicant's disclosure, and (3) the prior art references when combined must teach or suggest all the claim limitations. <u>See</u> <u>MPEP</u> § 2143. It is respectfully submitted that the combination of Hoyle and Il'in is insufficient to establish a prima facie case of obviousness of new claims 37 and 39.

1. There is no suggestion or motivation when the secondary reference would change the principle of operation of the primary reference.

In preceding Office actions addressing claims 1 and 7, Hoyle is considered the primary reference, and Il'in is citing as teaching that the detection of a single photon has a reasonable chance of success. As recited above, new claims 37 and 39 include the same limitations as previously addressed claims 1 and 7, and further require that the superconductor be maintained at a temperature substantially below its critical temperature such that the superconducting film is maintained in the superconducting state below the superconducting transition region.

A proper combination of references to support a rejection under 35 U.S.C. § 103 "cannot change the principle of operation of the primary reference." See MPEP § 2145, section III; see also, MPEP §2143.01. Hoyle teaches very accurately maintaining the detector temperature very near the critical temperature, but at a temperature so that the detector is in the superconducting state. See Hoyle, col. 5, lines 3-15 ("[f]or the film 52 to operate properly as a sensitive particle detector, its temperature must be maintained near the critical temperature for the superconductive material being used. Accordingly, accurate temperature regulation over long periods of time is important . . . the germanium sensor 46 illustrated in Fig. 2 and are capable of controlling temperature of the cryotip cold end to +/- 0.001K."); see also, Hoyle, col. 6, lines 8 – 18 ("To understand the mechanism by which detection occurs, it must be understood that the detecting strip is initially operated near its critical temperature and with a bias current that is near the critical current for that temperature. When in such a near critical state, impingement of a low energy particle on the wide portion of the detecting strip will raise the temperature of a small circular area above the critical temperature so that this small region of the detecting strip will go normal for a brief interval and then return to the superconducting state.").

In contrast to Hoyle, Il'in teaches that the detector described therein is maintained in a resistive state (i.e., not in a superconducting state as taught by Hoyle). See, e.g., Il'in, line 2, Abstract; and, Il'in pg. 1938, col. 2, ("This letter presents the experimental responsivity and determines the ultimate quantum efficiency of the HEP based on a thin NbN film in the resistive state.") (emphasis added); see also, Il'in, page 3939, first column, ("[p]ractically no photoresponse signal was observed at temperatures far above Tc, as well as below T=10K. . . .

Thus, our studied temperature range corresponded to the superconducting transition, i.e., near the maximum value of the dR/dT curve."). Note, the "R" and "T" in "dR/dT" refer to resistance and temperature, respectively.

The principle of operation of Hoyle involves maintaining the superconductor very near, but below the critical temperature, in the superconducting state so that detection of particles occurs based on a state change from the superconducting state to a resistive state. The principle of operation of Il'in involves maintaining the superconductor in a resistive state in the superconducting transition region where dR/dT is highest, i.e., where small changes in temperature cause the largest changes in resistance. Thus, for at least the reason that Hoyle operates to detect particles (i.e., 300 eV Argon particles) based on a state change whereas Il'in operates to detect particles based on resistance changes, it is believed that there is no suggestion or motivation to combine Hoyle with Il'in, and such combination does not render new claims 37 and 39 obvious under 35 U.S.C. § 103.

2. There is no reasonable expectation of success when the secondary reference specifically teaches away from the claimed temperature range.

As recited above, in preceding Office actions, Hoyle is considered the primary reference, and Il'in is citing as teaching that the detection of single photons has a reasonable chance of success. The combination of Hoyle and Il'in does not provide a reasonable expectation of success detection of a single photon (i.e., about 1eV) incident on the superconductor when the superconducting strip is maintained at a temperature substantially below its critical temperature such that the superconducting film is maintained in the superconducting state below the superconducting transition region, as required by new claims 37 and 39.

In the Niobium Nitride ("NbN") supeconducting detector discussed in Il'in, the temperature below which the NbN superconductor is in a superconducting state (the "critical temperature") is 11.7K. <u>See</u> <u>Il'in</u>, page 3938, col. 2. Il'in further teaches that "[p]ractically no photoresponse signal was observed at temperatures far above Tc, as well as below T=10K." <u>See</u> <u>Il'in</u>, page 3939, col. 1. Thus, Il'in expressly teaches that operation of a superconductor substantially below its critical temperature will <u>not</u> work for single photon detection. Thus, Il'in provides no expectation of success for single photon detection by modifying the Hoyle device for

operation substantially below the critical temperature such that the superconducting film is maintained in the superconducting state below the superconducting transition region. Thus, the combination of Hoyle in view of Il'in does not properly support a rejection of new claims 37 and 39 under 35 U.S.C. § 103.

3. The combination of Hoyle and Il'in does not teach or suggest single photon detection by a superconductor maintained substantially below its critical temperature such that the superconducting film is maintained in the superconducting state below the superconducting transition region.

It is recognized in preceding Office actions that Hoyle alone does not teach or suggest detection of single photons. There is a statement in Il'in suggesting the possibility of detection of single quanta of far infrared radiation, but only when the superconductor is maintained in a resistive state within the superconducting transition region (i.e. where dR/dT is highest). Thus, the combination of Hoyle and Il'in does not teach or suggest detection of single photons by a superconductor maintained substantially below its critical temperature such that the superconducting film is maintained in the superconducting state below the superconducting transistion region.

4. Conclusion

For at least the reasons recited above, it is respectfully submitted that new claims 37 and 39 are patentable under 35 U.S.C. § 103 over the combination of Hoyle and Il'in.

D. New dependent claims 38 and 40

New dependent claims 38 and 40, depend from and further limit new independent claims 37 and 39, respectively. Thus, for at least the same reasons recited above with regard to claims 37 and 39, it is believed that claims 38 and 40 are patentable under 35 U.S.C. § 103.

Additionally, claims 38 and 40 require a niobium nitride ("NbN") superconductor maintained at or below a temperature of about 4 Kelvin –10 Kelvin. Hoyle does not particularly address NbN superconductors. Il'in, however, discusses a NbN superconductor with a critical temperature (Tc) of 11.7K. Il'in further teaches that the properties of the NbN superconductor were tested within a temperature range of 4.2 Kelvin to 15 Kelvin. However, for the Il'in

detector, practically no photoresponse signal was observed at temperatures far above Tc, as well as below T=10K. As such, Il'in teaches that operation of the NbN superconductor must be in a resistive state in the transition region for detection to occur. Thus, Il'in teaches that modification of a NbN superconductor for operation below the superconducting transition region (i.e., in a superconducting state) would render it unsatisfactory for detection of particles. Moreover, Il'in teaches that operation of NbN superconductor in the range of about 4K to 10K should not work for detection of single photons. Thus, it respectively submitted that new dependent claims 38 and 40 requiring an NbN superconductor operating at or below between about 4K and 10K are not obvious under 35 U.S.C. § 103 in light of the combination of Hoyle and Il'in.

II. Rejection of Claims 20, 21, and 24 under 35 U.S.C. § 112, first paragraph

Besides consideration under 35 U.S.C. § 112, claims 20, 21, and 24 have not otherwise been examined on the merits. Upon overcoming the rejection of claims 20, 21, and 24 under 35 U.S.C. § 112, further treatment on the merits is respectfully requested.

In the May 14, 2003, Office action, claims 20, 21, and 24 are rejected under 35 U.S.C. § 112, paragraph 1, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventors had possession of the claimed invention at the time the application was filed. Additionally, the Examiner indicates that the "limitation 'at least one switching transistor' is not described in the original specification or drawings. In addition, it is not clear how a 'switching transistor' produces 'light emissions'." The rejections are respectfully traversed.

A. Claims 20 and 24

Claim 20 depends from claim 1, and includes "providing light from at least one switching transistor unto said biased superconducting strip, said light emissions comprising at least one single photon." Claim 24 depends from claim 7, and includes a similar limitation as claim 20. Particularly, claim 24 includes the limitation "wherein the superconducting film is configured to receive light emissions from at least one switching transistor, the light emissions comprising at

least one single incident photon." At page 4, line 34 and continuing to page 5, line 4, the specification of the present application states:

> Referring to Fig. 1A, an SSPD 1 detects photons 16 emitted by a light source 11, which includes suitable optics (not shown). It is to be understood that light source 11 is not necessarily a part of the photon counter 10 and is, for example, a transistor which emits photons when switching.

The above recited sentences are believed to describe the limitation of claims 20 and 24 in accordance with the requirements of 35 U.S.C. § 112, paragraph 1. As such, claims 20 and 24 are believed in proper form under 35 U.S.C. § 112, paragraph 1, and such indication is respectfully requested.

B. Claim 21

Claim 21 depends from claim 20, and includes the limitation "providing switching timing information about said at least one switching transistor." At page 4, line 34 – page 5, line 9, the present application states:

> Referring to Fig. 1A, an SSPD 1 detects photons 16 emitted by a light source 11, which includes suitable optics (not shown). It is to be understood that light source 11 is not necessarily a part of the photon counter 10 and is, for example, a transistor which emits photons when switching. Upon absorption of an incident photon, SSPD 12 in response generates an electrical output pulse signal that is amplified by associated amplifier 13. Each output pulse signal is recorded and counted by the data acquisition system (DAQ) 14 (e.g., a computer equipped with appropriate interface circuitry and software).

Further, at page 7, lines 30-35, the present application states:

> Because the output voltage pulse has a duration of only tens of picoseconds, SSPD 12 (and other SSPDs in accordance with this disclosure) can time resolve incident photon energy, and can distinguish between photons arriving at a very high rate (e.g., above 10^9 photons per second).

The above recited text of the present application, and other portions of the disclosure not cited above, describe the ability to detect photons emitted from a transistor when switching and the ability to time resolve the arrival of such transistor emitted photons. As such, it is believed that claim 21 is fully described in accordance with the requirements of 35 U.S.C. § 112, paragraph 1. Further, claim 21 is believed in proper form under 35 U.S.C. § 112, paragraph 1, and such indication is respectfully requested.

C. Switching transistor producing light emissions

It is believed that researchers at IBM first discovered that some transistors emit light or photons while switching. Reference is made to U.S. Patent No. 5,940,545 which describes an arrangement, including a photon counting multichannel optical detector, for receiving photons emitted by a switching transistor and analyzing the same. For the Examiner's convenience, the `545 patent is provided in the associated information disclosure statement. As the `545 patent does not involve a superconducting thin film single photon detector, or the arrangement of the same, the `545 patent is not considered materially relevant to the patentability of the various claims recited herein.

D. Conclusion

For the reasons indicated above, it is believed that previously submitted claims 20, 21 and 24 are properly supported by the specification. The examiner has indicated that the claims have not otherwise been treated on the merits. As such, upon an indication that the claims are allowable under 35 U.S.C. § 112, paragraph 1, further treatment on the merits is respectfully requested.

<u>III. Rejection of Claims 1-13 and 16-19 under 35 U.S.C. § 103 as being unpatentable over Hoyle in view of Il'in</u>

In the May 14, 2003, Office action, claims 1-13 and 16-19 are rejected under 35 U.S.C. § 103 as being unpatentable over Hoyle in view of Il'in. In pertinent part, the Examiner asserts that "Hoyle does not explicitly teach the use of this method for the detection of single photons, but one skilled in the art of light detectors would recognize the advantage of a detector with a sensitivity high enough to detect single photons." The Examiner further asserts that "[r]egarding the limitation 'time resolving said light directed unto said biased superconducting strip,' Hoyle describes the detection of switching from normal to superconducting states (col. 2, lines 5-9), which implies that the time resolving of light is an inherent part of the method."

A. Claims 1 and 7

Claim 1 has been amended herein to further define the operation of time resolving, such that claim 1 now includes the limitation "time resolving [said light] <u>said single photon</u> directed

unto said biased superconducting strip to resolve the incident time of the single photon to within or better than about 10 picoseconds." Independent claim 7 has been similarly amended.

It is well settled that "[t]he fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic." (emphasis added) MPEP § 2112; see also In re Rijckaert, 28 U.S.P.Q. 2d 1955 (Fed. Cir. 1992) (reversed rejection because inherency was based on what would result due to optimization of conditions, not what was necessarily present in the prior art).

The Examiner recognizes that Hoyle does not teach the detection of single photons. Thus, the device of Hoyle is not, and cannot be capable, inherently or otherwise, of determining the arrival time of the single photons to within or better than about 10 picoseconds.

Hoyle does not particularly provide any illumination about its ability to time resolve the 300eV Argon particles discussed therein. Instead, the method of Hoyle is primarily geared toward particle counting and other aspects, but does not discuss particle time resolving. More particularly, Hoyle explicitly teaches that the device described therein may be used in applications of particle counting, analysis of particle energy, and digital memories. See, e.g., Hoyle col. 5, line 4; col. 6, lines 33-35; col. 8, lines 15-17; col. 9, lines 35-40. In support of the rejection that time resolving of light, is an inherent part of the method of Hoyle, citation is made to col. 2, lines 5-9 of Hoyle, which describes the switching of the superconductor from a superconducting state to a normal state upon receiving a pre-determined amount of energy. The specification makes clear that this state change is primarily for photon counting, and also particle energy detection and digital memory. It could not be found where the Hoyle reference discusses time resolving of detected particles incident on the superconducting strip described therein. Thus, time resolving is not necessarily a part of the method of Hoyle.

Thus, it is respectfully submitted that claims 1 and 7, as amended, are not obvious over the combination of Hoyle and Il'in. As such, claims 1 and 7 are patentable and in form for allowance, and such indication is respectfully requested.

B. Dependent claims 2-6, 16, 17, 20-22, and 8-15, 18, 19, and 23-24

Dependent claims 26, 16, 17, and 20-22, depend from and further limit claim 1, and dependent claims 8-15, 18, 19, and 23-24 depend from and further limit claim 7. Thus, for at least the same reasons recited above with regard to claims 1 and 7, claims 26, 16, 17, 20-22, 8-15, 18, 19, and 23-24, are believed patentable under 35 U.S.C. § 103 and in form for allowance, and such indication is respectfully requested.

C. Dependent claims 16 and 18

With regard to claim 16 (depends from claim 2) and claim 18 (depends from claim 7), the Examiner indicates that the increase of output sensitivity from 0.1mV (taught by Hoyle) to 1mV (as provided in claims 16 and 18) would be within the ability of one of ordinary skill in the art. Hoyle states that "output pulse heights were found to be essentially the same [i.e., 100μV or 0.1mV] for a wide range of particle energies, i.e., for particles of energies between approximately 100eV and 1KeV. It is anticipated that the pulse height for some configuration of the present invention may remain linear for even larger ranges of particular energies." Thus, Hoyle teaches that pulse height is independent of particle energy. Hoyle further indicates that the pulse height should stay the same (i.e., 0.1mV) for a wide range of energies. The Examiner cites col. 8, ll. 28-30, and col. 9, ll. 12-34 of Hoyle as providing guidance on increasing the sensitivity of the Hoyle device. However, the sensitivity discussed in Hoyle relates to the sensitivity to detection of particles with different energies. See Hoyle, col. 8, l. 30. As taught by Hoyle, output pulse height is not dependent on particle energy. Thus, the guidance of Hoyle is not related to increasing output pulse height.

It is further submitted in the May 14, 2003 Office action that increasing the output pulse height is within the ordinary skill in the art. We respectfully disagree. Hoyle, arguably one of ordinary skill in the art, provides no guidance of increasing output voltage height, and suggests it will not vary over wide ranges of particle energies.

Additionally, Hoyle teaches that the superconductor is maintained very close to its critical temperature. There is an inverse relationship between temperature and critical current. As such, as the temperature decreases below the critical temperature, the critical current increases. Hoyle teaches that the detector is maintained very close to the critical temperature. Thus, any current in the superconductor must be very small to avoid transition into the resistive state. In contrast, with the method of claim 16 and device of claim 18 may be maintained substantially below the superconducting transition region where the critical current rises significantly and bias current in the superconductor may be maintained at substantially higher value without exceeding the critical current. Thus, a higher current may be employed in the detector of claims 16 and 18 without transitioning to the superconducting state. As is well known, Ohm's law provides that V=IR. By being able to provide a higher critical current value and still be superconductive, upon the superconductor of the present invention becoming resistive due to the detection of a photon, an accompanying higher voltage pulse is emitted by the detector of claims 16 and 18 due to the ability to provide a higher bias current. Being maintained close to the critical temperature, the device of Hoyle does not allow for such a high bias current, and thus cannot achieve a higher output pulse on the order of lmV in a manner taught by the present application.

Conclusion

For the reasons cited herein, it is believed that all pending claims 1-40 are patentable and in form for allowance, and such indication is respectfully requested. The Kadin and Johnson reference identified in the last Information Disclosure Statement is resubmitted herein as it appears the Examiner did not obtain the copy previously sent. This Amendment and Response is submitted with a petition for a three month extension of time to respond and the fee of $950.00 making this amendment due on or before November 14, 2003. This Amendment is also submitted with a fee of $546.00 for the additional claims. Finally, the accompanying IDS is submitted with a fee under 37 C.F.R. § 1.97(d) for $180.00. No additional fees are believed due; however, if any application processing fees are required, the Examiner is hereby authorized to charge deposit account number 190603.

If the Examiner has any questions or suggestions, please contact the undersigned at the telephone number listed below.

Respectfully submitted,

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